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Ye. V. Khrunov*

It is the second decade since the day of the first manned flight 13** into space — the flight of Yu. A. Gagarin on the spaceship "Vostok". Embarking on the space flight, the cosmonaut said, "To be the first in space, to put forth a one-to-one challenge in an unprecedented confrontation with nature — is it possible to ask more? But my next thought was of that colossal responsibility which lay on me. To be the first to do that which generations had dreamed of, to be the first to lay down a path for mankind in the cosmos. Name, if possible, a more complex task than that which fell to me. This responsibility is not towards one man, not towards scores of men, not towards the collective. This responsibility is towards the whole Soviet people, towards all of mankind, towards its present and its future."

The Soviet people are rightly proud of the fact that our country — the first country in the world to attain to socialism — became the birthplace of cosmonautics, and that the first man to set forth on a space flight was a citizen of the Soviet Union.

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** Numbers in the margins indicate pagination in the original foreign text.

There were dozens of manned space flights after the historic flight of Yuri Alekseyevich Gagarin. A great task has been fulfilled in a short period of time, and the most complex of experiments have been carried out. The space program is being fulfilled sequentially and purposefully. "Our path for conquering space", said General Secretary of the Central Committee of the CPSU L. I. Brezhnev upon the arrival of the cosmonauts, "is a path for the solutions of fundamental tasks and basic problems of science and technology. . . the Soviet Union considers the exploration of space as the great task of knowledge and of the practical development of nature in the interests of human labor, in the interests of peace on Earth."

The directives of the 24th Congress of the CPSU provide for the development of the economy of the USSR for 1971 - 1975 on a five-year plan; it guarantees the implementation of scientific projects in space, with the aims of developing long-distance communications, television, meteorological forecasting and the exploration of natural resources, geographical research and the solutions to other economic tasks with the aid of satellites, unmanned and piloted vehicles.

In fulfilling the wise directives of dear Comrade Leonid Ilyich Brezhnev, the meteorological space system "Meteor" was created, and is successfully functioning in our country. This system consists of satellites and a complex of ground equipment. With its aid, operative meteoroinformation is obtained and processed for the needs of the forthcoming total victory of communism on the Earth. This system will be developed and perfected. Along with automatic installations, a great role is played by orbital piloted laboratories in this program of investigation and development of space. /4

In a number of cases, man is more capable of carrying out scientific experiments, solving practical problems, analyzing its results and, when necessary, in changing the program, than a robot.

The invasion of space is a logical step in mankind's development. Following the development of vast territories of land, even greater spaces of water, and then the atmosphere, man started to storm the

frontiers of space. The possibility of sending scientific apparatus into space, and, subsequently, men-explorers, is a great achievement for science and technology. However, the flight of man into space has never been considered as an aim in itself. The effectiveness of each flight is always determined by the quantity and value of the fulfilled tasks and the obtained information. It is difficult to name a field of science which is not directly or indirectly interested in the results of space studies. Therefore, it is understandable that the program of each flight must be prepared as carefully as possible, and that the capabilities of the cosmonaut must be used entirely.

From the first space flight of Yu. A. Gagarin to orbital laboratories is the path which has been followed by Soviet cosmonautics.

The body of knowledge acquired by cosmonauts on board space vehicles has accumulated, and methods and means for the solutions of practical problems in the interests of economics have been developed.

In the first flight of Yu. A. Gagarin, the decisive factor was that man can survive in space in conditions of dynamic weightlessness; in subsequent flights, the number of experiments increased, and the spectrum of problems solvable in space became larger.

A natural development in modern cosmonautics were orbital stations of long-term functioning with crew shifts.

What are the means utilized for this?

Even today, the question of who should be prepared for space flights, a man or an automat, is debated, despite the fact that the experience acquired in space studies gives a convincing answer to this. Maximum effectiveness of the space program can be achieved through the optimal cooperation of the cosmonaut-operator and automatic technology.

Besides this, a wide body of tasks exists, the effective solution of which depends upon the degree of participation of

men-specialists, included in the crew, and properly trained for the fulfillment of these tasks.

The participation of man in the solution of scientific and practical problems on board these stations has definite advantages, such as the opportunity for conscious selection of objects for study, operative analysis of the given situation, selective transmittal of received data to Earth, visual observation of known and unknown phenomena, the possibility of decision-making based not only on information received during the flight, but also on the knowledge and experience of man, taking into consideration all objective and unforeseen factors.

The advantage of orbital laboratories lies in that the information obtained in them can be transmitted to Earth in "condensed" form. /5
If, for example, Earth is covered by cumulus clouds of good weather at the time of observation from a given point of orbit, there is no necessity to transmit information about cloudiness or pictures of cloudiness at each small region of the observed area. It is sufficient to report that the entire Earth's surface under the given orbit is covered by, namely, this type of cloud, and to characterize some of its peculiarities in condensed form (cloud banks, etc.). But when discussing frontal processes — central regions of cycles, thunderstorms, squalls, etc., the observations should become extremely detailed. This can be achieved with the aid of orbital laboratories which have cosmonauts-meteorologists on board. The cosmonaut, evaluating a given situation, must decide the degree of detail regarding the observation which is to be transmitted to Earth. In some cases, this may be T.V. or infra-red photographs of a definite large area; in other cases, it may be selected information about any particular characteristics valuable for forecasting. But in both cases, information should have large spatial resolution.

It is important to point out that such observations are required not only for forecasts. They will undoubtedly be required, for instance, for research of the active attempts to alter atmospheric processes. For these attempts it is not necessary to distribute

reagents along the entire surface to be altered. It is necessary to discover those regions which are most sensitive with respect to active influence. For example, the hail source in a cloud is shot at directly, rather than the cloud in general. The same can be said about the fight against the destructive forces of tropical cyclones, about the redistribution of intensity of precipitation connected with atmospheric fronts, etc.

Meteorological observations from space were begun by Yu. A. Gagarin, who stated after the flight that he not only clearly distinguished the shores of continents, islands, large rivers, land formations and farm fields, but also clearly saw clouds, and even their light shadows upon the Earth's surface. This information was completely confirmed by subsequent flights, and was the reason for including meteorological observations in the program of space flights.

Yu. A. Gagarin placed a high value on the possibility of visual observations from space. In subsequent flights, a large volume of visual observations was carried out, of processes and phenomena which take place in the atmosphere and on the Earth's surface. The degree of reliability and objectivity of visual observations was evaluated, and also the importance of systematic purposeful observations from space.

With the aid of automatic devices installed on board satellites, meteorologists are supplied with detailed information about the condition of the Earth's atmosphere; however, such detailed pictures as those made by cosmonauts are as yet unobtainable. Cosmonauts give the general characteristics of observed phenomena, their locations, and their possible speed and direction.

An especially valuable feature of meteorological information received during visual observations on board spaceships and stations, lies in the fact that this information is transmitted to Earth operatively and in a form which permits immediate use. This information is characterized by high authenticity and, therefore, it is almost

unnecessary to check the information received from cosmonauts; naturally, this economizes on time and means spent by specialists on the Earth.

In the future, when it becomes possible to include meteorologists in the crew of stations, the role this data will play in weather forecasting will become even greater. Aside from collecting factual data about the condition of the atmosphere in various regions of the Earth, these specialists will study means of correcting existing methods of weather forecasting, and developing new ones.

In observing the processes taking place in the Earth's atmosphere, it will be possible to operatively observe newly-originating atmospheric phenomena and to make timely reports about them to ground stations, especially those phenomena having a destructive nature — cyclones, typhoons, hurricanes, etc.

These phenomena may be visually observed by cosmonauts or recorded on film cameras. The cosmonauts choose which region of the phenomenon will be recorded on film, and on what scale. The photographs obtained by the cosmonauts with the aid of various photographic devices add to the information obtained through visual observation, and serve as an important means of studying the processes taking place in the atmosphere on a global scale. As a rule, these photographs have a high degree of detail and color accuracy, which is very important for the study of the microstructure of clouds. In contrast to aerial photographs, which can cover a sufficiently wide territory only by means of an aerial mosaic, photographs taken from a spaceship give an uninterrupted picture of large areas of the Earth's surface.

The history of the study of near space is, as yet, quite short, but it is evident that the economic effect of the results of these investigations, and the inclusion of them into meteorological weather forecasting services, may be very great. It will lead to an increase in the reliability of forecasts — especially long-term — and to timely information about potentially destructive phenomena.

Meteorological experiments carried out on spaceships and orbital stations are only the beginning of the forthcoming wide and many-sided meteorological investigations on the global scale with the participation of man. This pertains, first of all, to the solution of numerous problems of meteorological satellites.

It is already possible to give an approximate indication of the directions to be taken in the development of the function of cosmonauts in the interests of meteorology. These would be the study of the laws of the phenomena taking place in the atmosphere, and their recording; development of methods of discovering (observing) these processes and phenomena; development of the methods and means of informing ground services about visually observed pictures of the Earth's cloud cover.

The probable composition of the crew of orbital stations, working in the interests of meteorology, and the distribution of functional responsibilities, may be the following: the commander of the station directs orientation and stabilization, performs maneuvers and ensures control over fulfillment of the flight program, and carries full responsibility for it. The flight engineer controls the functioning of onboard systems. In case of a malfunction of a unit or system, he carries out an analysis of the situation and, if possible, eliminates the malfunction by replacing given parts of the system, or by putting substitute units to work. He controls manpower reserves and energy resources.

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The navigator ensures correct piloting of the station, and the smooth functioning of its radio and telecommunications.

The above-mentioned crew members must necessarily be included on board orbital manned stations. The composition of the second part of the crew will depend upon the tasks assigned to the orbital station. It will be composed of scientific workers, various specialists in science and economics, and others.

Such a crew composition will permit the presence onboard of specialists of a "narrow" profile — meteorologists, oceanographers, astrophysicists, etc.

The perfection of information-relay systems has increased the possibility of automatic flight control of the station. The role of the cosmonaut-operator on orbital stations is significantly greater than the traditional operational activity which, as a rule, consists of guiding the object along a previously worked-out scheme with the aid of various devices. The present-day cosmonaut is an investigator who works at solving various practical problems. He is an investigator because, while fulfilling a large program of scientific and practical tasks, he may meet with new, unknown phenomena and processes, which it is necessary to analyze and explain.

The experiments which have been carried out on manned spaceships and stations are undoubtedly only the first stage of broad and many-sided investigations on the global scale with the participation of man. This, in particular, pertains to the numerous inverse problems of meteorological satellites.

Although many aspects of synoptic and climatic processes are still unclear, or have not been sufficiently studied in the theoretical aspect, it is nevertheless certain that, on the one hand, the union of qualitatively new meteorological information and qualified cosmonauts-meteorologists, and — on the other — new effective methods of analysis, will ensure the perfecting of weather forecasting.

With respect to the practical and continuous utilization of meteorological information received from space, it will require the existence of permanent orbital manned stations with regular crew

changes and with definite work programs — work which will be fulfilled under the direction of experienced cosmonauts, who are specialists in the physics of the atmosphere.

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